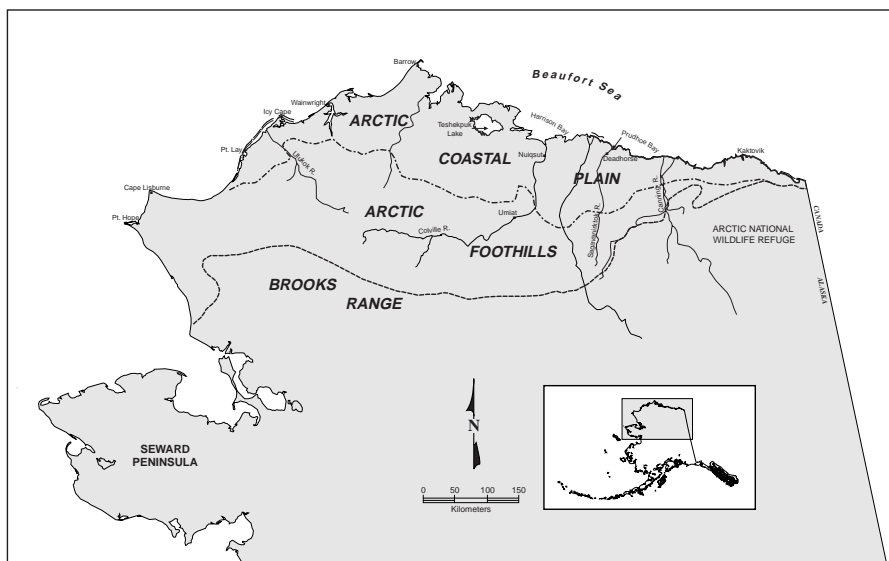


Understanding the Tundra Environment (Part 1 of 2)



An understanding of the tundra environment is critical when choosing tactics and strategies for treating a spill. Following is a general overview of major tundra types and their characteristics. Although this discussion focuses on Alaska's North Slope tundra, the planning, treatment, and monitoring tactics in this manual apply to tundra environments elsewhere in Alaska.

WHAT IS TUNDRA?

"Tundra" is a word used to describe the treeless landscape found north of the boreal forest and above tree line in the mountains throughout Alaska (Lincoln, 1987). Tundra occurs where extreme winter cold and wind, brief cool summers, and shallow continuous permafrost prevent trees from growing. Seasonal thawing of the surface layer of permafrost in arctic tundra creates an "active layer" of thaw a few inches to a few feet deep each summer. The rooting depth of plants and the infiltration of water are limited to this active layer. Tundra vegetation is characterized by low-growing plants including mosses, lichens, grasses, sedges, and dwarf shrubs. The extreme conditions found in tundra environments limit the variety of plants that can survive.

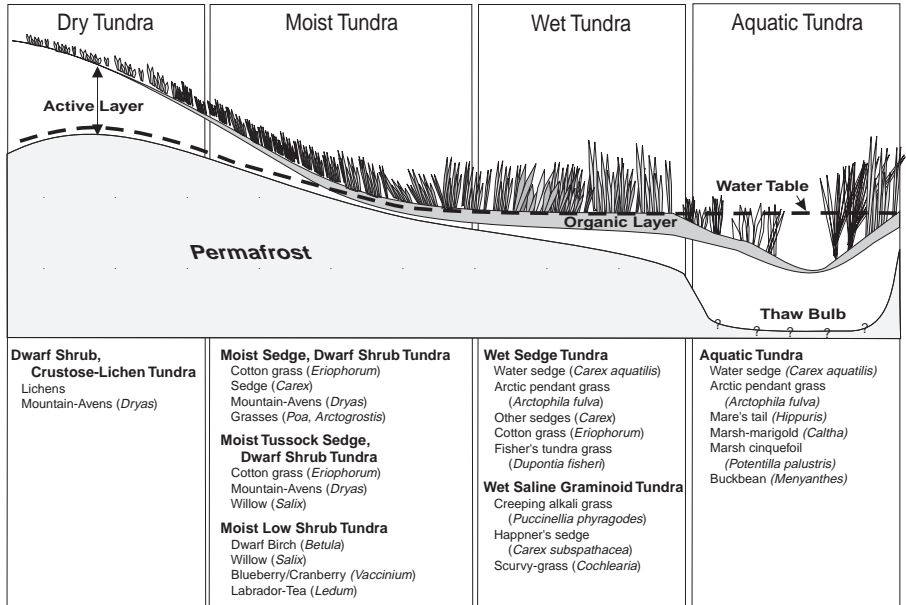
WHAT ARE THE TYPES OF TUNDRA?

The major tundra types recognized in Alaska are (Walker, 1983): ponds (aquatic tundra), marshes (wet tundra), bogs (moist tundra), and drier upland areas (dry tundra). These tundra types occur in three major geographic provinces on the North Slope of Alaska: 1) the coastal plain, 2) the foothills, and 3) the mountains of the Brooks Range, as well as on the Seward Peninsula.

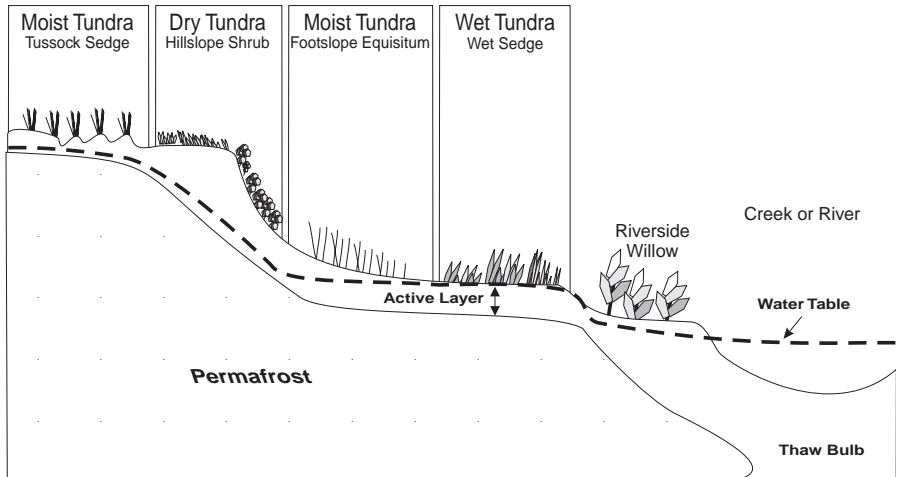
The coastal plain generally supports wet tundra due to the subtle topographic relief and the shallow, saturated active layer. Here, "patterned" or "polygonal" ground results from ice wedges or frost action. The foothills generally support moist tundra on the slopes, wet tundra in low areas, and dry tundra on the exposed hilltops and ridges. Polygonal ground is less common here. In the Brooks Range and in other mountain ranges in Alaska above the treeline, dry tundra predominates. High shrub thickets develop in floodplains in less exposed areas or where snow accumulates and protects plants from harsh winter winds. In the braided channels of the active floodplains, the soil surface is frequently barren.

The following drawings illustrate topographic features and subsurface conditions associated with the general types of tundra on the coastal plain (Walker et al., 1980) and in the foothills (Walker et al., 1989) of the North Slope. The example plant communities listed for the coastal plain are just a few of the common types among more than 30 community types that occur there.

Coastal Plain or Lowland Tundra Types



Foothills or Upland Tundra Types



Understanding the Tundra Environment (Part 2 of 2)

Aquatic Tundra

- **Occurrence:** Open water areas of ponds, lakes and streams. May occur as an extension of adjacent wet sedge tundra into ponds or lakes.
- **Common Plants:** Arctic pendant grass (*Arctophila fulva*), water sedge (*Carex aquatilis*), mare's tail (*Hippuris* spp.), marsh-marigold (*Caltha* spp.), marsh cinquefoil (*Potentilla palustris*) and buckbean (*Menyanthes* spp.).
- **Soils:** Thick layer of aquatic sediments made up of organic matter and peat.
- **Permafrost:** Deep at maximum thaw. Usually a "thaw bulb" below ponds, lakes, and streams caused by the water collecting heat from solar radiation.

Wet Tundra

- **Occurrence:** Where standing water persists through the growing season at depths less than 1 foot. Frequently along the margins of ponds, lakes and streams, in the low centers of polygon troughs, and within the wet areas of drained lake basins. This is the most common tundra type on the coastal plain. These are low-lying areas that accumulate melt water from adjacent higher ground due to the poor drainage.
- **Common Plants:** Aquatic emergent plants including arctic pendant grass (*Arctophila fulva*) or water sedge (*Carex aquatilis*) growing in standing water at the edge of ponds. Where the soil is saturated but without standing water, sedges and other grass-like plants thrive. Together these and many other wetland plants occur in a mosaic of open water, aquatic emergent vegetation, and stands of sedges.
- **Soils:** A layer of organic matter and roots forms a mat up to about 1 foot thick. The organic soil layer and root zone are thicker in wet tundra compared to dry or moist tundra. Ponds and standing water are typical at wet tundra sites, and soil pore spaces are saturated with water during the growing season.
- **Permafrost:** Moderate to deep at maximum thaw. The high thermal conductivity of the water can melt the upper layer of permafrost in the summer despite the insulating effects of the highly organic root mat. This *active layer* may extend to about 3 feet below the tundra surface in wet tundra.

Moist tundra

- **Occurrence:** Usually where the soil is saturated throughout the growing season and standing water is shallow or present for only a part of the growing season. Areas of moist tundra on the North Slope include the slopes of hills and the rims of polygons.
- **Common Plants:** Sedges (*Carex* spp.), cotton grass (*Eriophorum* spp.), dwarf shrubs like willow (*Salix* spp.), birch (*Betula* spp.) and mountain-avens (*Dryas* spp.), grasses, and broad-leaved herbaceous plants. A common type of moist tundra found in the foothills of the North Slope is tussock sedge tundra dominated by cotton grass (*Eriophorum vaginatum*), dwarf shrubs and *Sphagnum* moss.
- **Soils:** A dense, compressed root mat overlays silt or clay loam mineral soils.
- **Permafrost:** Active layer thinner than in wet or dry tundra due to the dense insulating organic mat and intermediate soil wetness.

Dry Tundra

- **Occurrence:** Where good drainage and a deep active layer create relatively dry soil conditions throughout the growing season. Throughout the slopes of mountain ranges, on ridges and hilltops in foothills, and on upland areas, stabilized dunes, pingos, and other well-drained locations on the coastal plain.
- **Common Plants:** Dwarf shrubs like birch, willow, blueberry and cranberry (*Vaccinium* spp.) and mountain-avens, evergreen shrubs like Labrador-tea (*Ledum* spp.), crowberry (*Empetrum* spp.), arctic bell-heather (*Cassiope* spp.), and manzanita (*Arctostaphylos* spp.) along with lichens, mosses, and grasses.

- **Soils:** Dry tundra soils have a thin root mat and low organic matter content compared to moist and wet tundra. Ample drainage reduces the ability of the thin root mat to hold moisture.
- **Permafrost:** The thaw depth usually is greater than 3 feet in dry tundra.

Why is Tundra So Sensitive to Disturbance?

Tundra environments are especially sensitive to disturbance for several reasons:

- Continuous permafrost
- Short growing season
- Extreme winter wind and cold temperatures

The tundra vegetation layer and root mat insulate the permafrost layer from the sun and warm surface air during the growing season. Surface disturbances can cause ice in the soil to melt, reducing the soil volume and causing subsidence (thermokarst). Drainage patterns are affected by subsidence, leading to further changes in topography and hydrology. Thermokarsting of dry or moist tundra could lead to formation of wet or aquatic tundra.

Tundra soils develop slowly in the Arctic, because the cold climate and short growing season limit the rate of plant matter decay by inhibiting chemical reactions and biotic activity. Water plays a major role in maintaining tundra vegetation on the North Slope. The combined water loss from evaporation and transpiration (water loss from plants) exceeds the precipitation received during the summer growing season. During June and July the water levels drop and then increase with precipitation in August, along with reduced evaporation and transpiration (lower temperatures and reduced plant growth). Wet and moist tundra, as well as ponds, capture and then lose the annual snowmelt runoff in the brief arctic summer. Annual evaporation and transpiration from wet and moist tundra exceed annual precipitation, and as a result, snowmelt runoff from surrounding upland areas is necessary to maintain wet conditions. Surface flow is usually observed only during and immediately following snowmelt. Subsurface water flow rates are generally low due to mostly impervious soil and low topographic gradients.

Why Are Spills on Tundra Difficult to Treat?

Treatment of spills to tundra is difficult for several reasons:

- Short summer season available when most treatments can be implemented
- Cold temperatures that limit biological activity and biodegradation
- Physical damage that may be caused by surface activities
- Remote locations and high mobilization effort
- Treatment is more complicated where patterned ground or tussocks occur

Acid or Alkaline Tundra?

The alkaline soil conditions of the coastal plain around the Prudhoe Bay oil field and along the Dalton Highway are unique for arctic tundra (Walker and Everett, 1991). Windblown dust from the Sagavanirktok River has deposited minerals that make the soil alkaline (pH>7), thus influencing soil and plant community development. Tundra treatment measures may vary depending on whether the soils are acidic (pH<7) or basic (pH>7). Arctic tundra is commonly acidic due to accumulation of peat and humic acids produced by peat.

The alkaline soil properties affect the types of plants able to grow in the affected areas. For example, shrubs like blueberry and cranberry (*Vaccinium* spp.), birch (*Betula* spp.), and some species of willows (*Salix* spp.) are less abundant in alkaline soil areas, whereas other plants such as mountain-avens (*Dryas integrifolia*) are more common in alkaline tundra than acidic tundra.